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DEVELOPMENT OF THE OCCUPATIONAL SAFETY AND HEALTH SYSTEM (OSHSYS): A DATABASE AND SOFTWARE PROGRAM FOR ANALYZING NAVY CIVILIAN INJURY AND ILLNESS DATA

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Development of the Occupational Safety and Health System (OSHSYS): A Database and Software Program for Analyzing Navy Civilian Injury and Illness Data

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SUMMARY

Problem

Payments totaled $224 million in 1998 for workers' compensation indemnity and medical benefits resulting from work-related injuries and illnesses among civilians employed by the Department of the Navy (DON). Mishap prevention programs to constrain these costs are in place, but better assessment tools are needed to evaluate the impact of these programs and to facilitate the development of more effective interventions.

Objective

The goal of this project was to develop a software and database tool for occupational health and safety experts to analyze the extent, nature, and costs of civilian work-related injuries and illnesses at DON worksites, to trace trends within a facility, make statistical comparisons of injury and illness incidence rates after adjustment for differences in workforce composition, and to identify the risk factors associated with these events. Such a tool can provide the assessment capability necessary to properly evaluate program effectiveness and safety performance.

Approach

To accomplish this task, historical data on civilian work-related injuries and illnesses, workers' compensation indemnity and medical payments associated with these incidents, and workforce profiles were collected and integrated into a relational database. A menu-driven software program using an actuarial-based cost accounting model was created to interactively analyze the data, generate long-term cost projections, and identify remediable problem areas to target for aggressive prevention and cost control efforts.

Results

The resulting analytic software program and database, referred to as the Occupational Safety and Health System (OSHSYS), was transitioned to Navy Occupational Health and Safety (N-45) where it has been distributed to local facilities. This tool can improve awareness of the costs associated with occupational injuries and illnesses; help managers determine more precisely where problems exist, thereby facilitating the informed and logical distribution of resources; provide models for predicting the more serious and costly mishaps to better target interventions; and offer a consistent method for comparing and assessing the results of occupational safety and health efforts across facilities. The capability to project long-term cumulative costs for annual cohorts of new cases enables Navy administration to finally hold supervisory personnel accountable for those costs specifically incurred under their command.

BACKGROUND

Civilian workers' compensation claims and medical payments have been slow to decrease—costing the Navy approximately a quarter of a billion dollars annually for the last several years and finally decreasing to $200 million—despite an ever-shrinking civilian workforce. This is because the older claims that are still active account a substantial proportion of any one year's bill. Mishap prevention and case management programs to control these costs have been implemented, but until the development of this system, there were no effective assessment tools available to accurately evaluate the impact of prevention efforts and return-to-work programs aimed at curtailing the costs of new cases. The Occupational Safety and Health System (OSHSYS) project, sponsored by the Chief of Naval Operations Occupational Safety and Health branch, N-45, was undertaken to develop just such an assessment tool. OSHSYS, the PC-based Occupational Safety and Health System, is a database and software program created to analyze civilian work-related injuries and illnesses occurring at Navy work sites.

OBJECTIVES

The objectives of this project were to develop a software and database tool that Navy managers and safety personnel at activities throughout the department could use to analyze the extent, nature, and cost of civilian work-related injuries and illnesses at Navy worksites, and to make comparisons between facilities after adjustment for workforce composition. These analyses would provide an assessment tool for judging the effectiveness of occupational mishap prevention and cost-control efforts. The ability to project long-term costs would allow Department of the Navy (DON) health and safety program managers, facility commanders, and local safety personnel to better gauge the effectiveness and savings benefit of prevention programs, hold managers accountable for the impact of their safety and health policies and practices, and identify early the potentially expensive cases so as to better focus both case management and preventive safety efforts.

APPROACH

The methodological approach to developing a useful analysis tool involved gathering data from multiple sources to build a comprehensive relational database, asking data-appropriate research questions, designing an analytical model to answer those questions, and then developing an interactive software program to help users mine the data to improve prevention policies and practices affecting health and safety.

A relational database using FoxPro® (Microsoft Corporation, Redmond, WA) was compiled using data from established Department of the Navy and Department of Labor databases—Navy civilian personnel and federal workers' compensation agencies, respectively—enabling the creation of *outcome variables,* such as incidence rates and mean cost per occupational injury or illness; *predictor variables,* such as occupation, work history characteristics, and facility type; and *potential confounding variables and covariates*, such as worker age or educational level. These variables were used for generating and testing statistical models to predict outcomes, such as occupational injury and illness rates and their associated costs.[1]

To accomplish these objectives, historical data on civilian work-related injury and illness claims, workers' compensation and medical payments associated with these incidents, and selected personnel and facility data were collected and integrated into SAS® (SAS Institute Inc., Cary, NC) data files and the FoxPro relational database. Annual data tapes containing information on individual injuries and illnesses among DON civilian employees were obtained from the Office of Workers' Compensation Programs (OWCP) for the years 1989 to 1995. Tapes for the same period containing personnel information for all members of the Department's civilian workforce were obtained from the Naval Civilian Personnel Data System (NCPDS). Social security numbers (SSNs) and dates of birth were used to link these two data streams. The resulting file was then linked by unit identification code (UIC) to a master file of Navy shore facilities.

The following is an overview of the methods used to create OSHSYS. This overview includes the steps taken to collect, clean, manipulate, and analyze the data, and a description of the data components.

A. Personnel data from the Naval Civilian Personnel Data System (NCPDS)

NCPDS data were used as the gold standard for workforce information employed in this project. NCPDS specifics on an individual's demographics, UIC assignment, occupation and career history proved to be more reliable than comparable OWCP data—the latter often self-reported by claimants on claim forms and prone to error. NCPDS records included 350,000 civilians who worked at Navy facilities during the 7 years of interest and consisted of approximately 2.2 million records.

1. The June 30th quarterly personnel data tapes were requested and received NCPDS. These tapes arrived each July with a June 30th "snapshot" of civilian population status: each employed civilian by UIC location, occupation, salary, and other career and demographic information. We compiled a total of 8 June 30th snapshots (1988-1995), each containing approximately 300 MB of data.

2. To create our own raw data files from these personnel tapes, the Extended Binary Coded Decimal Interchange Code (EBCDIC) files were copied from these tapes, translated into American Standard Code for Information Interchange (ASCII) files and retained as archival copies. Changes and discrepancies appearing in later records did not trigger a correction of earlier raw data records. After necessary data manipulations and corrections were completed, selected fields of interest were extracted and transferred to an NCPDS "new year" file. Additional calculations were then made, including the computation of annual salary.

3. Each individual's set of records has unchanging demographic fields plus dynamic fields that do change, such as UIC, occupation, and salary. We created "first records" and "last records" for each individual. The first record in an OWCP cohort file refers to the first record for a case (eg, the first data that report a new

injury). The first record in an NCPDS file refers to the first record for an individual/SSN. This original information received for a new case and a "new" individual was preserved in the first record. The last record refers to the most recent record received for a given OWCP case and the latest personnel record for an individual. In the case of discrepancies, demographic and injury data from the last records received were considered to be the most accurate and were used to provide the information associated with case occurrence. Hypothetical example: in 1991, Joe Avila, a white male born March 3, 1961, is first reported to have injured his left arm. He receives payments for the next 3 years. His 1994 OWCP records arrive with data presenting Joe Avila as a Hispanic male born March 3, 1960, who first injured his right arm in 1990. The latest data would replace all discrepant data in previous records except the first record. Then, since the year of injury has been corrected from 1991 to 1990, all of Joe Avila's case records would be removed from the 1990 cohort file and placed in the 1991 cohort file.

4. In most instances, earlier records were not corrected with later information. Several records were stored for one case, but it was the last record that was used in SAS files, intermediate FoxPro files, and OSHSYS tables to produce case counts, incidence rates, and costs.

5. Double records sometimes occurred due to overlapping UIC information. This was corrected by changing the start and stop dates of employment so dates would not overlap.

B. Injury and Compensation Data from the Office of Workers' Compensation Program (OWCP)

1. We obtained computer tapes from OWCP containing summary chargeback year (CBY) records for Navy civilians with active injury and illness claims. The OWCP CBY runs from July 1 through June 30 of the following year. Tapes were requested and received from OWCP by September of each year. Each tape contained individual records identified by SSN, an OWCP-assigned case number,

and case transactions for all medical and workers' compensation benefit payments made that year regardless of the year the injury or illness originally occurred. [2] These included summary records only and not OWCP's raw data files. The 7 ASCII files for CBYs 1989 through1995 were then manipulated and corrected as necessary. A comprehensive codebook for OWCP data was then compiled.[2]

2. Cases were sorted into cohort years (also July 1 through June 30) based on when the accident first occurred. A new cohort file was established each September with receipt of the new OWCP tape. We defined a case as belonging to a given accident year or "injury cohort" if the date of an individual's injury or diagnosis of illness fell within the July 1 through June 30 time-frame of the corresponding OWCP CBY. We began with 1990 through 1993 year tapes. The 1990 chargeback tape, for instance, contained records for 72 people first hurt in 1961, the only claimants that remain from an inception cohort that might originally have consisted of 20,000 to 25,000 workers. Data for this original cohort and its intervening history are not available, nor are complete data available for any cohort prior to 1989. Furthermore, the 18,743 new cases reported to OWCP in CBY 1990 and included on the 1990 tape do not constitute the entire 1990 cohort, however, because many newly occurring cases are not reported until later.

3. To identify late-reported cases, we searched subsequent chargeback tapes as we received them, retrieved all 1990 accident year cases and consolidated them into a single database. As subsequent records were added to the 1990 cohort, information updates (eg, a change in the reported date of injury) were placed in the "last record," preserving the "first record" for archival purposes. These records were then merged with NCPDS records in FoxPro using SSN and date of birth as the linking variables. "Permanent" data (eg, demographics, date of injury) from the last record were considered the most accurate and were therefore used for data analysis. "Dynamic" data (eg, successive CBY payment) from each successive record were used to establish year-by-year histories.

4. Extensive verification procedures were performed on the data using standard statistical techniques with SAS software. These included SAS contingency tables extracted from the cohort files to provide case counts. Two tables were created and used for these procedures: (a) total cases, last record, injury type by first tape-year, and (b) accepted-only cases, last record, injury type by first tape-year. Case count and payment data were then arranged vertically by accident year and horizontally by CBY of payment (see Tables 1 and 2).

5. Then first records for the new tape year were compiled: accepted-only cases, first record, injury type by first tape-year (tape-year cases only) and total cases, first record, injury type by first tape-year (tape-year cases only). Actual case counts were revised accordingly and were then used to update the persistency ratios employed to estimate the numbers of cases that would persist from year to year.

6. The actual payments for medical and compensation costs for each case appearing in the last OWCP tape were tabulated in SAS. Cases and their costs were sorted by cohort year and by injury/illness category: (1) no lost time injury, (2) back injury with less than 45 days of lost time, (3) injury other than back <45 days, (4) back >45 days, (5) injury other than back >45 days, (6) hearing loss, (7) emotional stress/mental, (8) sprains/strains, (9) asbestosis, (10) illnesses—other, (11) mortality: asbestosis, and (12) mortalities: non-asbestosis. These figures were then entered in summary spreadsheets using Excel® (Microsoft Corporation) capability.

7. Data extracts in the form of summary tables were then created in FoxPro for OSHSYS analysis software. Each year, new tables were used to replace the existing tables in OSHSYS.

C. Actuarial Model Created to Project Long-Term Costs

1. Precursor models predating the actuarial techniques ultimately adopted were described in a 1993 report by Shepherd et al.[3] With the assistance of actuarial

consultants, we later developed an algorithm that included a series of projection factors calculated from the historical data that dated back to 1961. The actuarial model was used to project cumulative payments through a specified period of time in the future as a function of these known inception-to-date payment histories. The primary technique employed was the loss development model—ratios that express the percentage change in costs from year to year based on prior experience. These ratios were then used to estimate future costs.[4]

Table 1. Department of the Navy Civilian Employee Injury Cohort Case Counts* by OWCP Chargeback Year

Injury year	Chargeback Year 1989	1990	1991	1992	1993	1994	1995	Cohort size through 30 June 1995
1961	76	72	67	62	64	57	54	
1962	81	81	80	72	68	68	66	
1963	83	80	77	69	69	68	66	
1964	106	100	99	95	87	79	72	
1965	119	119	117	113	110	104	100	
1966	136	133	117	112	113	110	102	
1967	175	166	160	149	139	126	126	
1968	229	224	201	202	197	194	173	
1969	271	254	228	213	214	206	189	
1970	318	307	282	273	264	247	233	
1971	369	344	312	289	275	260	250	
1972	434	409	384	364	344	337	316	
1973	501	474	440	446	418	399	387	
1974	568	535	501	461	450	442	412	
1975	565	540	508	484	461	440	424	
1976	685	673	653	627	559	553	520	
1977	785	773	755	726	630	637	616	
1978	646	590	585	548	532	510	484	
1979	708	655	586	575	520	506	492	
1980	652	612	583	566	523	514	488	
1981	660	622	593	554	511	477	480	
1982	681	643	575	569	555	532	496	
1983	777	708	662	597	585	565	523	
1984	962	816	770	698	659	611	591	
1985	1197	952	868	763	708	632	623	
1986	1827	1329	1167	993	878	770	711	
1987	3100	1757	1281	1004	891	745	672	
1988	9972	3187	1974	1400	1146	930	823	
1989	20102	10034	3380	2054	1474	1137	926	24,419
1990		18743	9672	3317	2204	1430	1101	22,682
1991			17303	8927	3435	1858	1241	20,815
1992				16929	9072	2944	1683	20,248
1993					15543	8542	2944	18,700
1994						14110	7543	16,777
1995							12888	12,888
Total	46,785	45,932	44,980	44,251	43,698	41,140	38,815	136,529

*Individuals newly reporting an injury or illness to OWCP, or, if previously reported, for whom a payment has been made during the chargeback year.

Table 2. Department of the Navy Civilian Employee Injury Cohort Payment Histories* by OWCP Chargeback Year

Injury year	Chargeback Year 1989	1990	1991	1992	1993	1994	1995	Inception to date**
1962	$ 964	1080	1075	1047	1006	954	808	
1963	1136	1299	1097	1105	1171	1119	1167	
1964	1402	1495	1538	1342	1344	1238	1234	
1965	1698	1765	1789	1622	1711	1668	1632	
1966	1723	1913	1715	1672	1530	1660	1625	
1967	2283	2319	2042	2039	2148	2150	1986	
1968	3111	3401	3061	3152	3169	3302	3140	
1969	3524	3445	3123	3161	3071	3053	2993	
1970	4291	4050	4186	4089	3985	4096	3525	
1971	4895	4352	4577	4180	4244	4181	4101	
1972	5590	5679	5510	5677	5698	5393	5116	
1973	6784	6724	6527	6660	6200	6034	5916	
1974	6673	6722	7224	6762	6729	6925	6759	
1975	7159	7169	6617	6696	6669	6490	6420	
1976	8252	8458	8324	7845	8041	7685	7981	
1977	8335	8038	8705	7983	7595	8159	7990	
1978	7387	7498	7638	7032	6832	6955	7156	
1979	7445	7224	7224	7453	6854	6951	7277	
1980	6065	6427	6230	5926	6192	6265	6277	
1981	6961	7301	6487	6546	6861	6651	6283	
1982	7028	7084	6490	6456	6813	6683	6537	
1983	8482	9192	7791	8136	7833	7930	7250	
1984	8988	9274	8961	9177	9153	8745	8066	
1985	10811	10878	9773	9273	9314	8493	8416	
1986	13908	12692	12021	11059	10252	10153	8911	
1987	16152	13999	12319	11316	10360	10244	9580	
1988	23572	18365	15329	14122	12931	12383	11439	
1989	12510	25126	18638	16588	13823	12960	10865	$110,510
1990		14955	26469	21473	17074	14327	12488	106,786
1991			13566	26747	19823	15288	12923	88,347
1992				14468	27425	19986	14666	76,545
1993					13702	28764	18978	61,444
1994						14411	24774	39,185
1995							11565	11,565
Total	$198,113	218,992	227,053	241,806	250,555	262,272	256,815	

*Totals for combined medical and compensation payments, in thousands of dollars.

**Not available for cohorts with inception dates prior to 1989.

2. Insufficient historical data were available to rely solely on a loss development model, so an empirical case persistency model that considers future counts and costs was also used. Persistency ratios are calculated as the proportion of cases that tend to persist from one year to the next based on prior experience, after standardizing case counts to reflect the number of employees originally at risk. These "persistent" case count projections are then multiplied by historically derived, per case expenditure estimates to produce future cost estimates.

3. We also calculated factors of up to 15% for delayed reporting of new claims because accidents or illnesses ensuing in one year may not be reported until later. We found that 99% of injuries, but only 86% of all ultimately claimed illnesses, were reported by the end of the second year following mishap occurrence.

4. To project future inflationary increases in medical costs and workers' compensation benefits, severity trends (inflation factors) were calculated using the Navy's own trend experience, the Consumer Price Index (Medical) and Department of Labor Cost-of-Living indices. Projected costs were then calculated in "nominal dollars" to reflect the impact of anticipated inflation on future benefit levels.

5. Point and interval prediction methods were also tested to evaluate the model.[5] Finally, projected costs of injuries and illnesses for each injury cohort were then broken down by facility and by a host of covariates defined in the User's Manual.[6] A description of the actuarial loss development model and its application to 1990-1993 OWCP CBY data was reported by Doyle et al.[7]

6. Each year, updated cost tables produced from newly received tapes were sent to actuarial consultants who revised existing loss development, persistency, and inflation factors for older cohorts and calculated new factors for the new CBY cohort. These factors were then used to estimate future costs for the new cohort and to revise cost projections for prior year cohorts.

D. OSHSYS

A menu-driven software program was developed to read FoxPro case frequency, cost, and workforce summary tables. The PC-based software allows users to select a naval facility for a given time period and perform five preset analyses. These include, for a given facility, injury and illness rates, crude and adjusted rates compared with Navywide rates and stratified by blue- and white-collar workforce segments, injury and illness costs, and a table and graph of the 12 occupations with the highest rates. Users can also perform a custom analysis, selecting from among five occupational categories (with 1000 selections), 10 demographic and career-related characteristics, and 5 injury/illness characteristics. These variables can be manipulated to produce rates and costs for stratified subpopulations of interest.

RESULTS

Data files were acquired from OWCP and NCPDS. The files were error-checked and corrected, then integrated into a relational database containing comprehensive demographic, occupational, and injury data for the DON civilian workforce for the period from July 1, 1988 to June 30, 1995. The linking of injury and personnel records allows person-level characterization of occupational and demographic risk factors for workplace injuries and illnesses.

A menu-driven software program for analyzing population subsets and reporting results was completed.[8] This database and software system, known as OSHSYS, provides for flexible and comprehensive characterizations of at-risk populations, injury events, and DON worksites. The at-risk data consist of extracts from more than 2 million personnel records describing civilians who worked for DON during the period covered. The event data consist of records for 136,529 mishaps in active claim status during this same time period. Standardized reports provide crude and adjusted injury rates for any of the 2032 facilities that employed civilians between 1988 and 1995 to be compared with Navywide rates for the same time period. This report also identifies the 12 occupations at highest risk

for injury and illness at each facility. Customized reports allow the user to examine injury rates and associated costs of category-specific facility subpopulations based on workforce or injury characteristics, and to compare these with Navywide rates and costs.

OSHSYS version 1.0 provides 34-year cost projections for 10 individual injury categories using an actuarial model. Standardized and customized analysis and reporting capabilities provide the user with crude and adjusted injury and illness rates for any of the 2032 facilities that employed civilians between 1988 and 1995, estimated costs associated with those injuries and illnesses, and standardized incidence ratios comparing each facility's rates and costs with Navywide figures for the same time period. Requesting the same analysis for successive years at a given facility can identify safety and performance trends. In addition, a table and a graph identifying the 12 occupations at highest risk for injury and illness at each facility can be produced for each year. Finally, OSHSYS allows the user to examine the injury rates of category-specific subpopulations based on workforce and injury characteristics. A complete description of the analyses available in OSHSYS is available in the User's Manual. OSHSYS features are outlined in Table 3.

The assembled database, actuarial model, and software should allow for improved oversight of the Navy's Occupational Safety and Health Program. The use of actuarial methods to determine the long-term cost of an injury or illness makes it possible to affix an economic value to occupational injury and illness prevention efforts, and will thereby facilitate comparisons of the costs and benefits of various programs, policies, and interventions. Similarly, the merging of person-level event and population data allows the calculation of incidence rates (crude, adjusted, or category-specific), which in turn makes it possible to examine and compare the efficacy of safety programs at different facilities or to identify problem areas within individual facilities. For instance, a facility with a low overall injury rate might still be found to have a higher than average rate within a single occupation, and such a finding would suggest a need for an intervention focused specifically on that occupation.

Table 3. OSHSYS 1.0 Analytical Elements, Features, and Benefits

OSHSYS version 1.0 has been designed to provide a number of analytical elements. Chief among these features, OSHSYS:

- Identifies what type of mishaps are occurring at each activity
- Provides rates for specific occupations and for different workforce segments
- Estimates the long-term costs of those injuries
- Identifies the more costly types of mishaps
- Offers a consistent method for comparing the safety performance of commands and evaluating the results of occupational safety and health efforts across facilities
- Is designed to adjust for differences in workforce composition
- Permits activities to compare their respective injury rates with Navywide rates to better assess both their strengths and areas where they need improvement
- Allows the Navy to hold people accountable for the costs specifically incurred under their command
- Supports epidemiological analysis to begin identifying the causal factors for workplace injuries and illnesses
- Helps target prevention and intervention strategies
- Enables assessment of the effectiveness of those interventions

OSHSYS can improve awareness of the costs associated with occupational injuries and illnesses and the savings potential inherent in their reduced incidence. It allows managers to determine more precisely where problems exist, thereby facilitating the informed and logical distribution of resources—providing models for predicting the more serious and costly mishaps, enabling more focused intervention and resource allocation. OSHSYS offers a consistent method for comparing the results of occupational safety and health efforts across facilities. The capability to project long-term cumulative costs for annual cohorts of new cases enables Navy administration to hold supervisory personnel accountable for those costs specifically incurred under their command. To the best of our

knowledge, none of these capabilities have been available within any component of the Department of Defense.

A published report presented research findings that excessive numbers of workers' compensation claims are filed on Mondays and on Tuesdays following Monday holidays, and that almost a quarter of all claims for sprains and strains purported to occur on these days are likely to be fraudulent.[9] A separate analysis to identify the predictors of longer duration (and high cost) claims using the Cox's proportional hazard model revealed that claimant age, injury type, occupational class, and OWCP reporting district were all independent predictors of claim duration.[1] This study modeled the persistency of workers' compensation cases in the DON civilian workforce. Characteristics of longer duration cases included illnesses (in general) and upper extremity sprain and strains, 46 years of age and older, and cases handled in the Washington, DC, OWCP district office. In the 1989 cohort—along with the illnesses, age, and district characteristics—being female and making more than $40,000 per year were also important predictors of longer duration cases. Study findings suggested that focusing prevention and case management efforts on these workers might contribute to savings in compensation costs.

OSHSYS 1.0 on CD-ROM was transferred to Chief of Naval Operations, Environmental Protection, Safety, and Occupational Health Division (N-45). Program documentation, materials, and support were also provided. This division has assumed responsibility for the subsequent reproduction, distribution, and operational implementation of the program. Local activities can now use OSHSYS to evaluate in detail the health and safety conditions at their commands. Occupational safety and health managers and commanders can use OSHSYS to assess performance and intervention effectiveness, pinpoint risk areas and problems for remediation, and identify exceptional performance for commendation.

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13. ABSTRACT ***(Maximum 200 words)***

Payments totaled $224 million in 1998 for workers' compensation indemnity and medical benefits resulting from work-related injuries and illnesses among civilians employed by the Department of the Navy. Mishap prevention programs to constrain these costs are in place, but more effective assessment tools are needed to evaluate the impact of these programs and to facilitate the development of more effective interventions. The Naval Health Research Center supervised the development of a software and database tool enabling occupational health and safety experts to analyze the extent, nature, and costs of civilian work-related injuries and illnesses at DON work sites, to trace trends within a facility, and make statistical comparisons of mishap rates after adjustment for differences in workforce composition. Such a tool can help management properly evaluate program effectiveness and safety performance, and target remediable problem areas for aggressive prevention and cost-control efforts.

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